3D printing

Conference Paper · December 2014

CITATIONS
0

READS
67,372

1 author:

Samer Mkhemer
Birzeit University
15 PUBLICATIONS **1** CITATION

SEE PROFILE

Faculty of Engineering and Technology

Electrical and Computer System Engineering Department

Electrical Machine Drives and Special Machines (ENEE5303)

Term Paper

"*3D Printing Technology*"

Prepared by:

Name: Samer Mukhaimar	Number: 1110727
Name: Saed Makhool	Number: 1040403
Name: Qais Samara	Number: 1110598

Instructor: Dr. Muhammad Abu-Khaizaran.

Section: 1

Date: 12 / 11 / 2014

Table of contents:

Scientists and engineers are impressing us daily with revolutionary technologies that turned what was recently considered as science fiction or inconceivable futuristic into reality, making our lives much easier and more interesting. For example have you ever imagined being able to make your own designed glasses frame, kid's toys, or any other prototypes at your home using raw materials and a single machine? The *3D printing* technology enables you to do this and it has much more complicated applications in science and industry.

This is an analytical research paper in which the reader is introduced to the 3D printing technology, its definition, history, basic components, and operation theory.

So what is this technology? There are a lot of similar definitions and terminologies used to describe *3D printing such as: additive manufacturing, and rapid prototyping.* However, all of them describes the main distinguishing idea from ordinary subtractive methods which is Additive manufacturing. Generally speaking, ***3D printing****:* is a process by which 3D solid objects of any shape or geometry can be created from a digital file. The creation is achieved by laying down successive layers of a specific material until the entire object is created. Each of these layers represents a thinly sliced horizontal cross-section (similar to the output of an ordinary printer, this is why it is called printing) of the eventual object, in contrast to traditional subtractive manufacturing methods which relies upon the removal of material to create something.

The history of 3D printing technology:

3D printing is a new technology, the birth of 3D printing was in 1984 at the hands of Chuck Hull who invented a process known as stereolithography, in which layers are added by curing photopolymers with UV lasers, after that, 1990 layer by layer technology used each layer has 0.1mm depth, in 1999 the first use in medicine, in 2000 the first parts of human such as ears, fingers was done, 2005 3D printing technology became open source, in 2006 the first SLS (selective laser sintering) machine become variable, in 2008 the first self-replication printer which made the printer able to print the majority of its own components also at the same year 3D technology developed to do a very hard shapes and artists for designers ,in 2009 Atom by atom printing were done which allows for Bio3D printing, in 2011 the first 3D printer Robotic Aircraft at the same year the world's first 3D-printed Car and it became commercially available at the next year, at the same year the first gold and silver jewelry were done using 3D printer.

The main components of a 3D printer:

A 3D printer includes a set of components that operate simultaneously to produce the desired output from the input digital file, the basic components of a 3D printer are listed below:

1. Print Bed (Tray)

This is the flat surface where the 3D models are layered during printing. The print bed may be ambient or heated Depending on the filament types used in the printer. Heated print beds are used to keep the printed section of the print warm during the layering process to prevent warping.

2. Extruder:

The extruder is the part that thrusts out and feeds the plastic filament (or any other filament) into the 'hot-end'. Extruders are typically incorporated into the hot-end, however in some types it can be remote, pushing the filament through a tube, called a Bowden cable, into the hot-end. In some types a dual extruder is used, which provides the ability to print two different materials at the same time. This added feature result in increased price, as it requires an extra extruder, and hot end.

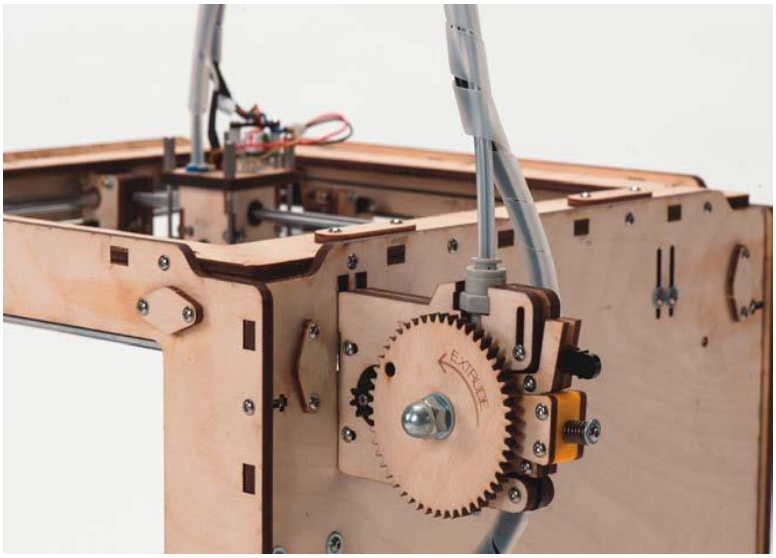

Figure.1: *A Bowden extruder*

3. Hot-end:

The hot-end is composed of a heat source, a temperature sensor, and an extrusion tip where plastic filament is fed though to deposit molten material, it is often confused with the extruder. The hole in the slot may range in size, typically between 0.2mm and 0.8mm. The smaller the nozzle, the more detailed the print, but the longer it takes for the thinner layers to stack up.

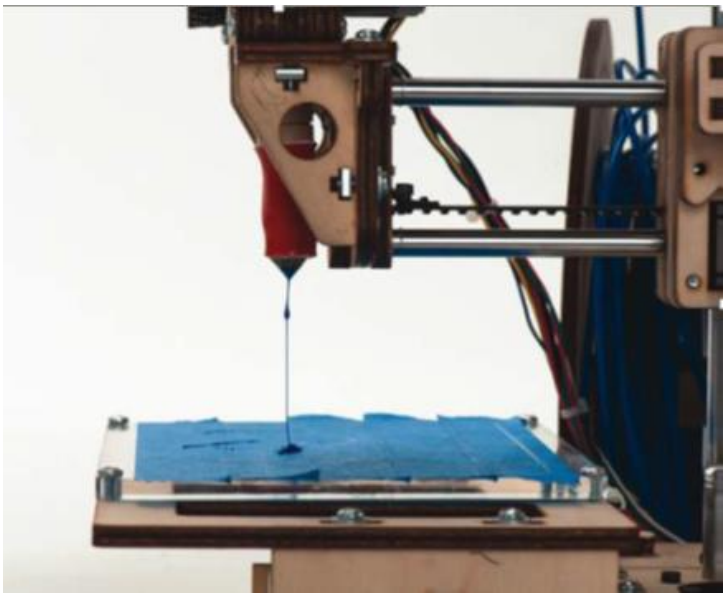

Figure.2: *The Printrbot hot-end / extruder*

4. Filament

The filament is the input material which is formulated as a 3D solid object by the printer. Like an inkjet inject ink, a 3D printer emits melted filament.

Operation of a 3D printer:

The process of 3D printing (transforming a digital file into solid object) is a quite long and complicated one. These process is described in the following 4 steps below:

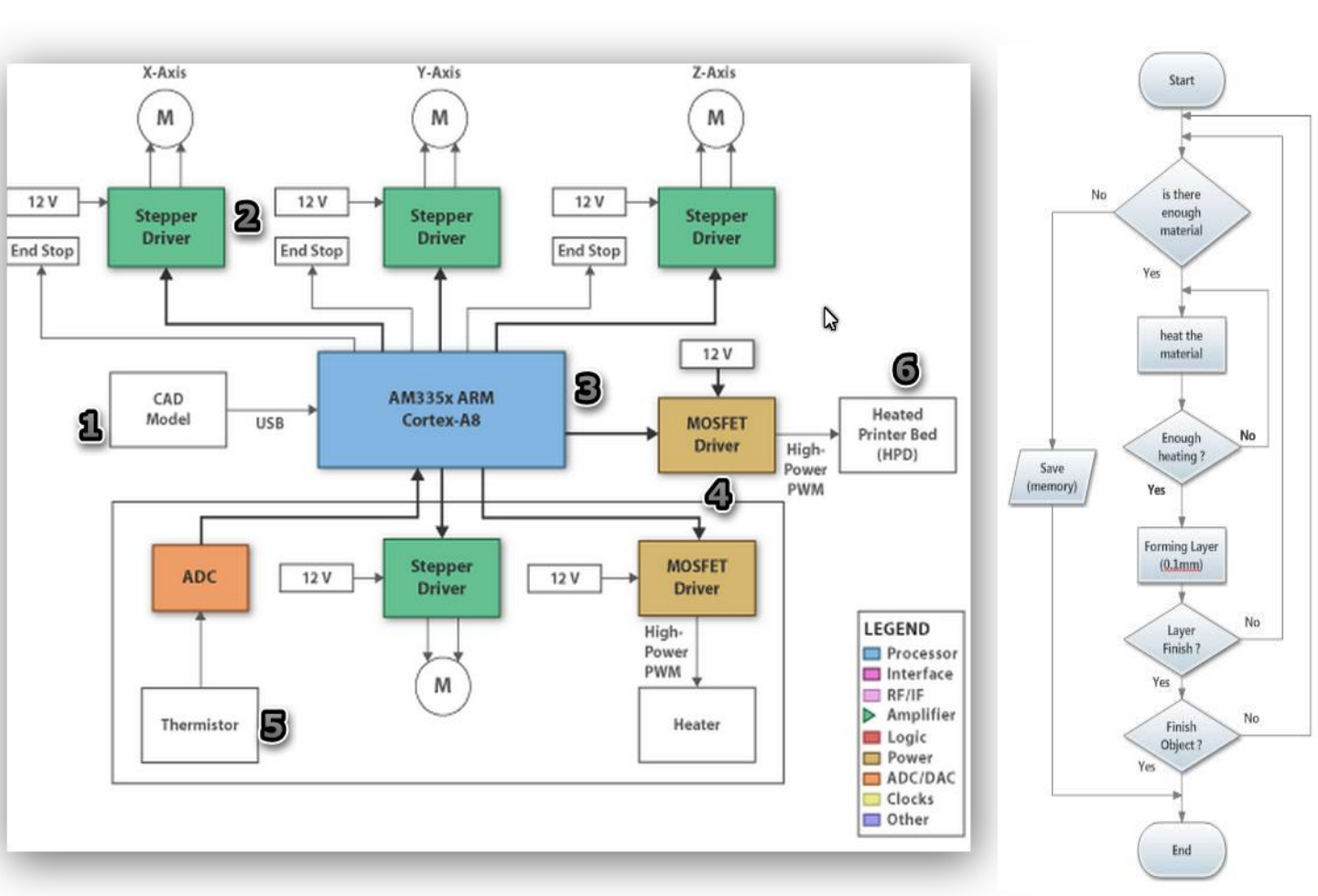

Figure.3: (A): Block diagram of 3D printer. (B): Flow chart of 3D printer operation.

Step I: (CAD)[3] file — is created using a 3D modeling program, either from scratch or beginning with a 3D model created by a 3D scanner. Either way, the program creates a file that is sent to the 3D printer. Along the way, software slices the design into hundreds, or more likely thousands, of

horizontal layers. These layers will be printed one atop the other until the 3D object is done. Many programs are used for designing 3D object such as Solidworks, AutoCAD and have a steep learning curve, there are a number of other programs, many free that are very easy to learn. The free version of Google SketchUp, for example, is very popular for its ease of use; and the free Blender program is popular for its advanced features.

Step II: **(motoring)** the operating of 3D printer requires motoring with low torque, high accuracy the best motor to do this function is **stepper motor:** : is an electromagnetic device that converts digital pulses into mechanical shaft rotation. Advantages of step motors are low cost, high reliability, high torque at low speeds and a simple they are a special type of synchronous motors which are designed to rotate a specific number of degrees for every electric pulse received by its control unit, a fraction of degree could be done using gears in order to move the printer head a specific displacement, in 3D printer four stepper motors were needed to do the specific function, three of them were used for moving in X,Y,Z direction of the printer head, the 4th one was needed to move the plate(bed).

Step III: (processing) The AM335x microprocessors are enhanced with image, graphics processing, and industrial interface options. The device supports the following high-level operating systems (HLOSs), The AM335x microprocessor contains these subsystems 1) Microprocessor unit (MPU) 2) Graphics Accelerator subsystem for 3D graphics acceleration to support display. allowing independent operation and clocking for greater efficiency and flexibility. As the ability to scale in speed from 600MHz to greater than 1GHz.

Step IV: (MOSFET drive) Bipolar stepper motor with MOSFET drive, which will allows the motor to move in both direction, since stepper motor is open loop system, high accuracy component will used in order to print in the specific place, so that MOSFET was used, because it has a fast frequency operation.

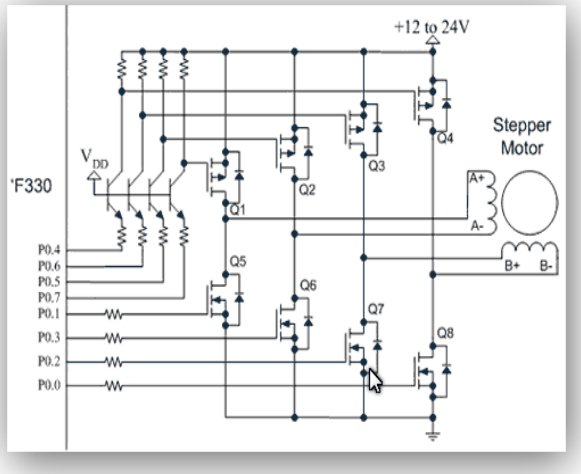

Figure.4: MOSFET Drive of a stepper motor

Current 3D printing technologies:

There is a variety of printing technologies (processes) to create physical objects from digital designs. The main differences between these processes are in the way layers are deposited to create parts and in the materials that are used. Some methods melt or soften material to produce the layers, while others cure liquid materials using different sophisticated technologies. Each method has its own advantages and drawbacks. Here are some common technologies:

- **Stereo lithography** – (SLA): position a perforated platform just below the surface of a vat of liquid photo curable polymer. A UV (Ultra Violate) laser beam then traces the first slice of an object on the surface of this liquid, causing a very thin layer of photopolymer to harden. The perforated platform is then lowered very slightly and another slice is traced out and hardened by the laser. Another slice is then created, and then another, until a complete object has been printed and can be removed from the vat of photopolymer, drained of excess liquid, and cured.
- **Fused deposition modelling (FDM)**: Here a hot thermoplastic is extruded from a Temperature-controlled print head to produce fairly robust objects to a high degree of accuracy.
- **Selective laser sintering (SLS)**: This builds objects by using a laser to selectively use together successive layers of a cocktail of powdered wax, ceramic, metal, nylon or one of a range of other materials.
- **Multi-jet modelling (MJM):** This again builds up objects from successive layers of powder, with an inkjet-like print head used to spray on a binder solution that glues only the required granules together.

Pros and cons of 3D printing:

Some of the pros of 3D printing are listed below:

- Manufacturing complexity is free: In traditional subtractive manufacturing, complicated designed object's shape are more difficult to make. On a 3D printer, complex or simple objects requires the same effort.
- Variety is free: A single 3D printer can make many shapes, in contrast to traditional manufacturing machines which are much less versatile and can only make things in a limited range of shapes.

- No assembly required: 3D printing produces interlocked parts. In modern factories, machines produce identical components that are later assembled by robots or human workers. Complicated designed objects include many parts, which takes a longer time to assemble and the more expensive cost to make.
- Zero skill manufacturing: traditional manufacturing machines still demand a skilled expert to adjust and calibrate them however, a 3D printer gets most of its guidance from a design file. To make an object of equal complexity, a 3D printer requires less operator skill than does a traditional subtractive machine hence less money and cost.
- Compact, portable manufacturing. Per volume of production space, a 3D printer has more manufacturing capacity than a traditional manufacturing machine. For example, an injection molding machine can only make objects significantly smaller than itself. In contrast, a 3D printer can fabricate objects as large as its print bed. If a 3D printer is arranged so its printing apparatus can move freely, a 3D printer can fabricate objects larger than itself. A high production capacity per square foot makes 3D printers ideal for home use or office use since they offer a small physical footprint.
- Less waste by-product: 3D printers create less waste by-product than do traditional metal manufacturing techniques therefore, educing losses and increasing the efficiency.

Some of the pros of 3D printing are listed below:

- Decrease in Manufacturing Jobs: this con is controversial, as with all new technologies, manufacturing jobs will decrease. This disadvantage can have a bad result to the economies of third world countries that depend on a large number of low skill jobs.
- Limited Materials: any given printer can use only a specific material or a narrow range of materials. So printing different products requires different printers or modifications on a single printer.
- High cost at professional high level industrial applications.
- Copyright: With 3D printing, the printing of copyrighted products to create counterfeit items will increase and nearly impossible to determine or prevent.
- Dangerous Items: if everyone would be easily able to 3D print guns and knives with his printer, without oversight, the violence rates will grow.

- Size: Currently, 3D printers are limited with the size of the products that they can create so to print larger more complicated objects one requires larger printers hence higher cost.

In summary, 3D printing is no more a fancy, it is spreading widely in a variety of applications, from simple domestic use to complicated industrial applications with decreasing cost and increasing efficiency. Some experts argue that these printers will be the drive of a coming revolution that will change the whole face of industry, and that it will be a basic part of every home in accordance with the decrease in cost (less than 1000$ for small personal printers).

List of References:

H. Lipson, M. Kurman, 1st Initial. , *Fabricated: The New World of 3D Printing*, 1st edition, Indiana: John Wiley & Sons, Inc., 2013, p.

E. Canessa, C. Fonda, M. Zennaro, *Low-cost 3D Printing for Science, Education & Sustainable Development*, 1st edition, : ICTP—The Abdus Salam International Centre for Theoretical Physics, 2013.

K. France, *Make: 3D Printing*, 2nd ed., Gravenstein Highway North, Sebastopol: Maker Media,, 2014, p.

http://www.engineering.com/3DPrinting/3DPrintingArticles/ArticleID/6262/Infographic-The-History-of-3D-Printing.aspx

http://3dprinting.com/what-is-3d-printing/#whatitis

http://3d.about.com/od/Other-Resources/tp/The-Ten-Principles-Of-3d-Printing-By-Hod-Lipson-and-Melba-Kurman.htm

http://www.ti.com/lsds/ti/arm/sitara_arm_cortex_a_processor/sitara_arm_cortex_a8/am335x_arm_cortex_a8/products.page

http://www.philforhumanity.com/3D_Printing.html

http://www.appropedia.org/Humboldt_3D_printer_workshop#Motor_System: